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VOICE CALL ALTERNATIVE ROUTING  
THROUGH PSTN AND INTERNET NETWORKS

RELATED APPLICATIONS

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This application is related to application Serial No. 08/634,544, entitled Universal Access Multimedia Network, filed April 18, 1996, application Serial No. 08/634,543, entitled Internet Telephone Service, filed April 18, 1996 and application Serial No. 08/670,908, entitled Internet Telephone System, filed June 28, 1996. The specifications of those applications are incorporated herein by reference in their entirety.

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TECHNICAL FIELD

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The present invention relates to telecommunications networks and more particularly to transporting voice calls alternatively through an Internet path or the public switched telephone network (PSTN) in dependence upon Internet service quality.

BACKGROUND OF INVENTION

Implementation of voice telephone service over a worldwide data network, such as the Internet, offers

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advantages that are now being explored. The Internet had its genesis in U.S. Government (called ARPA) funded research which made possible national internetworked communication systems. This work resulted in the development of network standards as well as a set of conventions for interconnecting networks and routing information. These protocols are commonly referred to as TCP/IP. The protocols generally referred to as TCP/IP were originally developed for use only through Arpanet and have subsequently become widely used in the industry. TCP/IP is flexible and robust. In effect, TCP takes care of the integrity and IP moves the data. Internet provides two broad types of services: connectionless packet delivery service and reliable stream transport service. The Internet basically comprises several large computer networks joined together over high-speed data links ranging from ISDN to T1, T3, FDDI, SONET, SMDS, OT1, etc. The most prominent of these national nets are MILNET (Military Network), NSFNET (National Science Foundation NETwork), and CREN (Corporation for Research and Educational Networking). In 1995, the Government Accounting Office (GAO) reported that the Internet linked 59,000 networks, 2.2 million computers and 15 million users in 92 countries.

A simplified diagram of the Internet is depicted in Fig. 1. Generally speaking the Internet consists of Autonomous Systems (AS) which may be owned and operated

by Internet Service Providers (ISPs) such as PSI, UUNET, MCI, SPRINT, etc. Three such AS/ISPs are shown in Fig. 1 at 52, 54 and 56. The Autonomous Systems (ASs) are linked by Inter-AS Connections 58, 60 and 62.

5 Information Providers (IPs) 64 and 66, such as America Online (AOL) and Compuserve, are connected to the Internet via high speed lines 68 and 70, such as T1/T3 and the like. Information Providers generally do not have their own Internet based Autonomous Systems but have or use Dial-Up Networks such as SprintNet (X.25), DATAPAC and TYMNET.

By way of current illustration, MCI is both an ISP and an IP, Sprint is an ISP, and MicroSoft (MSN) is an IP using UUNET as an ISP. Other information providers, such as universities, are indicated in exemplary fashion at 72 and are connected to the AS/ISPs via the same type connections, here illustrated as T1 lines 74. Corporate Local Area Networks (LANs), such as those illustrated in 76 and 78, are connected through routers 80 and 82 and links shown as T1 lines 84 and 86. Laptop or PC computers 88 and 90 are representative of computers connected to the Internet via the public switched telephone network (PSTN), shown connected to the AS/ISPs via dial up links 92 and 96.

25 The Information Providers (IPs) are end systems that collect and market the information through their own servers. Access providers are companies such as UUNET,

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PSI, MCI and SPRINT which transport the information. Such companies market the usage of their networks.

In simplified fashion the Internet may be viewed as a series of gateway routers connected together with computers connected to the routers. In the addressing scheme of the Internet an address comprises four numbers separated by dots. An example would be 164.109.211.237. Each machine on the Internet has a unique number that includes one of these four numbers. In the address, the leftmost number is the highest number. By analogy this would correspond to the ZIP code in a mailing address. The first two numbers that constitute this portion of the address may indicate a network or a locale. That network is connected to the last router in the transport path. In differentiating between two computers in the same destination network only the last number field changes. In such an example the next number field 211 identifies the destination router. When the packet bearing the destination address leaves the source router it examines the first two numbers in a matrix table to determine how many hops are the minimum to get to the destination. It then sends the packet to the next router as determined from that table and the procedure is repeated. Each router has a database table that finds the information automatically. This process continues until the packet arrives at the destination computer. The separate packets that constitute a message may not travel the same

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path, depending on traffic load. However, they all reach the same destination and are assembled in their original order in a connectionless fashion. This is in contrast to connection oriented modes such as frame relay and ATM or voice.

Software has recently been developed for use on personal computers to permit two-way transfer of real-time voice information via an Internet data link between two personal computers. In one of the directions, the sending computer converts voice signals from analog to digital format. The software facilitates data compression down to a rate compatible with modem communication via a POTS telephone line. The software also facilitates encapsulation of the digitized and compressed voice data into the TCP/IP protocol, with appropriate addressing to permit communication via the Internet. At the receiving end, the computer and software reverse the process to recover the analog voice information for presentation to the other party. Such programs permit telephone-like communication between Internet users registered with Internet Phone Servers. The book "Mastering the Internet", Glee Cady and Pat McGregor, SYBEX Inc., Alameda, CA, 1994, ISBN 94-69309, very briefly describes three proprietary programs said to provide real-time video and voice communications via the Internet.

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Hemmady et al. U.S. Patent No. 4,872,160, issued October 3, 1989, for Integrated Packetized Voice and Data Switching System, discloses an integrated packetized voice and data switching system for metropolitan area networks.

Sampat et al. U.S. Patent No. 5,493,568, issued February 20, 1996, for Media Dependent Module Interface for Computer Based Conferencing System, discloses a media dependent module interface for computer based conferencing system. An interface connects the upper-level data link manager with the communications driver.

Koltz bach et al. U.S. Patent No. 5,410,754, issued April 25, 1995, for Bi-Directional Wire Line to Local Area Network Interface and Method, discloses a bi-directional wire-line to local area network interface. The system incorporates means for packet switching and for using the internet protocol (IP).

The commonly assigned applications, Serial Nos. 08/634,543 and 08/670,908, identified more particularly above, are concerned with providing telephone service via the Internet to users of the public telecommunications network who may not have access to a computer or separate telephone access to the Internet. Such service would be economical, especially for long distance calls, compared with the toll rates charged by long distance interexchange carriers.

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With increasing volume of use on the Internet and the bursty nature of data transmission, traffic patterns have become unstable and unpredictable. The minimum quality of service acceptable for voice communication is much higher than the level for data transport as transmission delays noticeably degrade conversation. With the Internet or other high volume data network, acceptable voice communication may be available between two end points at a given time, but often not at other times. A surge in data traffic may make the network unsuitable for voice communication for as much as twenty or thirty minutes. Bottlenecks may occur at different points in the network at different times. The locations of the participants of a voice call are factors in determining suitability of the data network. The degree to which degradation of a voice call remains acceptable is subjective with the user and can be a tradeoff between quality of service and reduction of cost.

A deficiency in earlier proposed voice Internet service systems is the inability to ensure an acceptable level of service quality. The data packet network traffic in the connection paths of a voice call may render intolerable transmission delays. Current systems do not measure delays against user acceptable standards. The voice call user must either endure such a call or terminate the call in favor of originating a new call through an alternative system.

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## BRIEF SUMMARY OF THE INVENTION

The present invention overcomes the above noted drawbacks of earlier proposed systems and provides additional advantages in part by utilizing the advanced intelligent network (AIN) to determine routing of voice calls alternatively between the public switched telephone network (PSTN) and a data packet network, such as the Internet, in accordance with the quality of service existing in the data packet network at the times of call origination. The user's acceptable level of service may be predefined with a threshold quality level stored in the user's Call Processing Record (CPR) in the AIN Integrated Services Control Point (ISCP). On a per call basis, the caller linked to a first public switched network may indicate a preference to route through the Internet. This indication is recognized by the AIN system, in response to which the quality of service currently present on the Internet for completion of the call is measured. If the result exceeds the stored threshold, the call is setup and routed through the Internet to the switched network link to the destination party. If the quality of service on the Internet is not satisfactory, the call is alternatively routed through the PSTN, which may include an Interexchange Carrier link. The AIN system automatically controls the alternative routing of such calls. The Interexchange Carrier selection may be made in accordance with a

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carrier identified in the calling subscriber's CPR or the ISCP may determine routing through a default carrier in accordance with a global routing scheme.

5 The invention thus provides the advantages of enabling a caller to indicate, individually for each call, a preference for that call to be routed through a packet data network if the performance of that network is currently acceptable. If not, routing of the call is made through the PSTN in normal fashion. The route  
10 actually undertaken in this process is transparent and undetectable to the caller at the time of the call.

Additional advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description, wherein only the preferred embodiment of the invention is shown and  
15 described, simply by way of illustration of the best mode contemplated for carrying out the invention. As will be realized, the invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without  
20 departing from the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

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## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a simplified diagram of the Internet.

Fig. 2 is a simplified block diagram of a Public Switched Telephone Network (PSTN) that comprises a Common Channel Interoffice Signaling (CCIS) system and voice communication network that perform as an Advanced Intelligent Network (AIN) system.

Fig. 3 is a simplified block diagram of an AIN controlled PSTN, such as the type shown in Fig. 2, which includes architecture for implementing Internet routing in accordance with one preferred embodiment of the invention.

Fig. 4 is a diagram of the functional architecture of one embodiment of an Internet Module for use in the system and method of the invention.

Fig. 5 is a block diagram that represents the functionality of the processor interface 112 and the router 110 shown in Fig. 4.

Figs. 6A and 6B taken together form a simplified flow chart that illustrates operation of preferred embodiments of the invention in which service is provided on a per call basis.

Fig. 7 is a partial simplified flow diagram for the preferred embodiment of the invention in which service is provided on a predefined basis.

## DETAILED DESCRIPTION OF THE INVENTION

Fig. 2 is a depiction of the AIN architectural environment that is considerably simplified for explanation purposes. The full network and operating environment for the invention may comprise multiple central offices, diverse interconnections, and provisions for reliability through redundancy, all of which need not be shown for developing an understanding of the invention. Service Switching Points (SSPs) 11, 13, 15, 17 represent central office (CO) switching systems that are appropriately equipped programmable switches present in the telephone network. Subscriber lines individually connect SSPs to subscriber premises at which locations telephones 12 or other communication devices are connected. As well known, the SSPs recognize AIN type calls, launch queries to the ISCP and receive commands and data from the ISCP to further process the AIN calls. In the illustrated embodiment, the CO-SSPs are end offices.

SSP capable central office switching systems typically contain a programmable digital switch with CCIS communications capabilities. One example of an SSP capable CO switch is a 5ESS type switch manufactured by AT&T. Other vendors, such as Northern Telecom and Seimens, manufacture comparable digital switches that may serve as the SSPs. A more detailed description of an exemplary SSP type CO is presented in the commonly

assigned copending application, Serial Number 08/248,980, filed May 25, 1994, hereby incorporated by reference herein.

5 The SSP type COs 11 and 13 are shown connected to a first local area STP 23, SSP-COs 15 and 17 being connected to a second local area STP 25. The connections to the STPs are for signalling purposes. The control part of SS7 protocol is known as Integrated Services Digital Network User Part (ISUP). ISUP determines the  
10 procedures for setting up, coordinating, and taking down trunk calls on the SS7 network.

Each local area STP can connect to a large number of the SSP-COs, as indicated for ease of illustration merely by the circles below STPs 23 and 25. The central office  
15 SSPs are interconnected to each other by trunk circuits for carrying telephone services. The overall network may contain end offices without SSP functionality. Such end offices will forward calls to one of the SSPs if such treatment is required. Also, certain switching offices  
20 within the network, whether SSPs or not, may function primarily as tandem type offices providing connections between trunk circuits only.

The local area STPs 23 and 25, and any number of other such local area STPs (not shown) communicate with  
25 a state or regional STP 31. The state or regional STP 31 in turn provides communications with the ISCP 40. The STP hierarchy can be expanded or contracted to as many

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levels as needed to serve any size area covered by the Advanced Intelligent Network (AIN) and to service any number of stations and central office switches. Also, certain switching offices within the network, whether SSPs or not, may function primarily as tandem type offices providing connections between trunk circuits only.

The links between the central office switching systems and the local area STPs 23 and 25 are typically SS#7 type CCIS interoffice data communication channels. The local area STPs are in turn connected to each other and to the regional STP 31 via a packet switched network. The regional STP 31 also communicates with the ISCP 40 via a packet switched network.

The messages transmitted between the SSPs and the ISCP are formatted in accord with the Transaction Capabilities Applications Protocol (TCAP). The TCAP protocol provides standardized formats for various query and response messages. Each query and response includes data fields for a variety of different pieces of information relating to the current call. For example, an initial TCAP query from the SSP includes, among other data, a "Service Key" which is the calling party's address. TCAP also specifies a standard message response format including routing information, such as primary carrier ID, alternate carrier ID and second alternate carrier ID and a routing number and a destination number.

The TCAP specifies a number of additional message formats, for example a format for a subsequent query from the SSP, and formats for "INVOKE" messages for instructing the SSP to play an announcement or to play an announcement and collect digits and a "SEND TO RESOURCES" message to instruct the SSP to route to another network node. Reference is made to the aforementioned copending application, Serial Number 08/248,980, filed May 25, 1994, for a more detailed description of the AIN network.

The ISCP 40 is an integrated system shown that contains a data base. In the AIN network system, certain calls receive specialized AIN type processing under control of data files stored in the ISCP data base. Such files contain call processing records (CPRs) associated with respective AIN subscribers. Information contained in the CPRs relate to the AIN service or services to which the customer subscribes. The SSP type local offices of the public telephone network include appropriate data in their translation tables for customers subscribing to AIN services to define certain call processing events identified as AIN "triggers". The SSP uses the translation table data to detect a triggering event during processing of calls to or from such AIN service subscribers. Upon detection of such event, the SSP suspends processing of a call and activates a query and response type AIN interaction with the ISCP. Completion of call processing ensues after

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sufficient information is exchanged between the SSP and the ISCP. For ordinary telephone service calls that are not subject to enhanced treatment, there would be no event to trigger AIN messaging. The local and toll office switches would function normally and process such calls without referring to the SCP data base for instructions.

Fig. 3 is a simplified block diagram of an AIN controlled PSTN, such as the type shown in Fig. 2, which includes architecture for implementing Internet routing in accordance with one preferred embodiment of the invention. It is to be understood that the Internet representation in this figure, as well as throughout this disclosure, is illustrative of any packet network of routers that allows voice traffic to be packetized and sent over a shared network. The use of the phrases "Internet" and "data packet network" or the like are used interchangeably throughout this description. In Fig. 3, wherein like reference numerals are used for corresponding elements of all other figures, there are shown two SSP capable central offices 13 and 17 which may be located in the same or different states and regions. These central offices are connected by trunks 14 and 16 respectively to the PSTN indicated by a cloud 10. Each central office is connected by local loops to subscribers customer premises equipment (CPE) such as telephone terminals 12 and PC 90. The telephone 12 may be a

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practice, such as shown in Fig. 1 and described in related application Serial No. 08/634,544, referenced above. An interface with processing capability is illustratively shown at 112. Connected to the router are a Domain Name Service (DNS) server 114 and a Dynamic Host Configuration Protocol (DHCP) server 116 of the type conventionally used by Internet Service Providers in existing Internet Service. The router interface is connected to the central office and to the CCIS network while the router is connected to the Internet.

Fig. 5 is a block diagram that represents the functionality of the processor interface 112 and the router 110. The processor contains a common Generic Data Interface (GDI) 120 for communicating signaling messages with the ISCP in the telephone network. Upon prompt from the ISCP, through the GDI, a quality test application in the processor can be initiated for determining whether a call is to be routed through the Internet. Data communication by the gateway router of both signaling and information content through the Internet (or other equivalent packet network) occurs through TCP/IP protocol 124, packets being transmitted and received through physical transport layer 126. The physical transport layer may comprise Asynchronous Transfer Mode (ATM), frame relay or some other type of data communication mode.

While message and signaling communication with the ISCP occurs through the GDI, communication of voice data is made through the Channel Serving Unit, Digital Serving Unit (CSU/DSU) 128. This unit, which may physically  
5 comprise a digital line card in the processor with standard 24 digital voice line inputs, packetizes voice data received from the telephone central office. The CSU/DSU performs line coding, line-conditioning and equalization functions, and responds to loopback commands  
10 from the central office. Including functions similar to a modem, the CSU/DSU can pass data at a range greater than 56 Kbps. The CSU/DSU coordinates with route determination unit 130 to identify packets, termination phone numbers and routes to the network termination  
15 gateway router. The route determination information is included in each packet for the data received from the originating central office SSP. The packetized data is compressed in accordance with stored algorithm 132, before being sent to the TCP/IP stack and physical  
20 transport layer for transmission to the far end gateway router. To complete transmission to the destination telephone, the termination router decompresses the received packets, depacketizes back to voice data which is then routed to the destination PSTN. Two way  
25 capability for each of the functions is provided for communication in both directions. While shown for illustrative purposes as separate blocks, the route

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basis, for example, by placing a call to a specified virtual telephone number or through an operator.

At step 202 a determination is made at the caller's central office SSP whether to trigger a TCAP message to the AIN ISCP, whereupon processing of routing for the call is temporarily suspended. Triggering will occur in response to entry of the service code. This may be followed immediately by the dialed telephone number or a dial tone may be returned to the caller after the trigger for subsequent entry of the dialed telephone number. Alternatively, triggering can be initiated by calling a virtual number or an operator, after which the destination telephone number is input.

If a trigger has not been detected at step 202, the call is routed in normal fashion through the PSTN network at step 204. If a trigger has been detected, the originating central office SSP formulates a TCAP query message to the ISCP at step 206. The ISCP will recognize from the caller's CPR that the call is to be placed through the Internet (or equivalent data network) if the quality of service in that network meets an acceptable threshold level identified in the CPR of the calling party.

Before proceeding further, the ISCP determines through the SS7 signaling network, at step 208, whether the call destination station is busy. If so, the call is terminated with a busy signal transmitted to the calling

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party at step 210. As an alternative to the SS7 network determination, busy/non-busy status at the destination station can be determined through the Internet. In this alterative, the ISCP can signal the GDI interface of the local router to route through to the destination router interface to the destination PSTN for the inquiry.

If the destination station is not busy, the ISCP will send a message to the local gateway router to perform a quality of service test at step 212. If the local gateway GDI interface is unable to accept the message or the CSU/DSU unit of the router is fully occupied, as determined at step 214, the ISCP will instruct the originating SSP to complete the call through the PSTN at step 204. If the local gateway router is available, as determined at step 214, the GDI initiates the quality test application at step 216.

The performance of the quality of service test may comprise the sending of one or more data packets, known in the art as a "PING" signal, from the local router to the destination router and measuring the response time. PING, which is an acronym for Packet InterNet Groper, is a program used to test reachability of destinations by sending them an Internet Control Message Protocol (ICMP) echo packet request and waiting for a reply. The test packet signal generated by the quality test application is formatted for transport through physical layer 126 and the Internet to the destination end gateway router. As

a more sophisticated alternative, the test application can format a sample packet with RSVP protocol that includes a bandwidth reservation for all routers that will transmit the call through the network. A measure of PING performance quality is the time delay taken for the signal to traverse the circuit, and variance of such delays in successive test transmissions. In the case of bandwidth reservation, an acknowledgement back from the destination that a specified minimum bandwidth level has been reserved is a measure of performance quality.

From the response back from the destination router, the test application obtains a quality of service level that is signaled back to the ISCP. This level is compared with an acceptable threshold level stored in the caller's CPR at step 218. If the level is not up to the acceptable level of quality, routing of the call is controlled by the AIN, which will terminate any data network activity for the call at step 220 and handle call routing as in step 204.

If it is determined at step 218 that the quality of service in the data network is acceptable, the ISCP will signal the local router, at step 220, to transmit a message to the destination router to initiate a call through the destination PSTN to the destination station.

The path for transmission of the voice data through the data network will have been determined by the CSU/DSU unit 128, in conjunction with route destination unit 130,

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either when bandwidth had been reserved or, in the case of acceptable PING test result, in response to the ISCP signal received in step 218. The ISCP, at step 222, will send a TCAP message to the originating central office SSP to complete the call to the local router CSU/DSU port allocated for the call. Outgoing voice signals received by the CSU/DSU from the originating location will be compressed by unit 132, formatted using TCP/IP protocol and physically transported over the data packet network. Incoming packeted voice signals will be decompressed for transmission through the local PSTN to the origination location.

Fig. 7 is a partial simplified flow diagram for the preferred embodiment of the invention in which service is provided on a predefined basis. This figure illustrates only steps in which the call processing flow varies from the operation flow of the embodiment of Figs. 6A and 6B. Thereafter, the embodiment proceeds to step 208 of Fig. 6A. That is, for this embodiment the steps 200 through 204 are replaced with the steps shown in Fig. 7. Placement of a call by a subscriber at step 300 initiates an off-hook trigger at the associated central office, step 302. The central office, in turn, suspends processing of call routing to formulate a TCAP message, transmitted to the ISCP at step 304. At step 306, the ISCP determines whether the information received in the TCAP message matches a predefined condition stored in the

CPR of the calling subscriber. As indicated above, the CPR may contain a list of destination telephone numbers, area codes, times of day or week, or any combination of such criteria by which an attempt to rout a call through the Internet is to be attempted. Other criteria such as considered desirable by a subscriber can also be included.

If no predefined condition stored in the CPR has been recognized to identify the call as an Internet call in step 306, the call will be routed in normal fashion through the PSTN at step 308. If an Internet routing attempt is indicated at step 306, the process continues in accordance with Figs. 6A and 6B at step 208 and the steps thereafter.

It can be appreciated that the use of the AIN network to control routing of telephone calls alternatively through the PSTN or Internet in accordance with this invention will ensure quality of voice communication while taking advantage of available network economies. While the per call basis and predefined basis services have been described above as separate embodiments for simplicity of explanation, these services can be combined into a single service. A subscriber thus can be given the option for any given call to expand the predefined conditions stored in the subscriber CPR, destinations and time of day listings for examples, by inputting a code, such as \*82. The ISCP would be

5           Only the preferred embodiments of the invention and  
but a few examples of its versatility are shown and  
described in the present disclosure. It is to be  
understood that the invention is capable of use in  
various other combinations and environments and is  
10 capable of changes or modifications within the scope of  
the inventive concept as expressed herein. For example,  
ISCP determination of whether routing may be made through  
the data network may be made in response to triggering  
initiated at an SSP other than the calling party  
15 originating SSP. The SSP 13 of Fig. 3 instead may be an  
intermediate SSP at the point of presence (POP) of an  
interexchange carrier that is linked to the originating  
caller SSP. The selection field in the SS7 ISUP message  
received by the SSP at the POP would indicate that  
20 routing through Internet is preferred if the quality of  
service in that network is acceptable. The use of the  
intelligent network to route the call to completion at  
that point is then under control of the interexchange  
carrier. As a further alternative, a dedicated trunk can  
25 be connected to the interexchange carrier SSP for all  
such calls.